SOME ENCLOSURES IN MUSCOVITE.

BY H. CARVILL LEWIS.

In order to gain an insight into the method of occurrence of the crystals of biotite enclosed in muscovite, examples of which occur in several localities, the writer prepared, some seven years ago, a series of cleavage plates taken from a single crystal of muscovite and biotite. These sections, arranged in order consecutively from the base of the crystal upwards, are now delineated upon the accompanying plate, and exhibit several features of interest. The specimen figured is one of a number found at an opening in partially decomposed felspathic gneiss on Baltimore avenue, West Philadelphia. The decomposition which, due to exposure to atmospheric agencies, has more or less attacked all the minerals at this place, has either partially or completely altered the enclosed biotite into a hydrous exfoliating mineral, which, bearing the same relation to unaltered biotite as margarodite does to muscovite,[1] may be known as hydro-biotite.[2] The unaltered biotite is black, the hydro-biotite brown—both substances generally appearing in the same crystal.

The enclosed crystals of biotite have frequently well-defined edges, and contrast sharply with the surrounding white muscovite.

It is of interest to observe that, so far as noticed, the crystallographic axes of both muscovite and biotite are parallel, and their prismatic planes symmetrical. Where, owing to the imperfect development of the enclosing muscovite, this relation is not immediately perceptible, it may be rendered evident by producing in each substance a strike figure (*schlag figur*), by mechanical means. If a sharp-pointed steel rod is held lightly upon a thin piece of mica, and the rod is then struck quickly with a hammer, a hole is produced in the mica, from which radiate lines of cleavage in three directions. As Reusch has shown,[3] the cleavage in biotite (hexagonal) is parallel to the sides of the hexagon, while in

[1] *v.* Proc. Acad. Nat. Sc., Phila., 1880, p. 319.

[2] Margarodite being merely a hydrated muscovite, similar to it in all optical and physical characters, except such of the latter as are due to alteration, should properly be called *hydro-muscovite.*

[3] Monatsb. d. Konigl. Acad., Berlin, 1868, p. 428 ; 1869, p. 84.

muscovite (orthorhombic) two of the cleavage lines are parallel to the sides of the rhomb, and the third parallel to the shorter lateral axis (brachydiagonal). The two micas have, therefore, similar strike figures, the lines of one being parallel to those of the other. In each strike figure the lines cross each other at angles of 60°. If now a strike figure is produced close to the dividing line between the two micas, it will be seen that if the biotite is unaltered the cleavage lines run continuously from the one into the other without change of direction—a proof that the crystallographic planes of the two micas also have the same direction. This fact has already been shown by Gustav Rose[1] in a specimen of biotite in muscovite from Alstead, N. H.

Since, therefore, the two micas have symmetrically arranged prismatic planes, it is probable that they have been crystallized together out of the same solution.

A close examination of the accompanying plate, exhibiting a continuous *vertical* section of the crystal, shows that while the edges of both crystals remain parallel in successive plates, the substance of the biotite is gradually absorbed or eaten away, and replaced by the encroaching muscovite as the summit of the biotite crystal is approached. In fig. 1 the nearly perfect black crystal of biotite is seen to occupy a large space within the muscovite. Fig. 2 shows a small patch of white muscovite within the black crystal, while in figs. 3 and 4 this small patch is seen to become larger and the biotite to diminish in quantity. As the muscovite increases, the biotite diminishes. In fig. 7 the biotite is confined to one corner of the crystal. It still decreases until in fig. 11 only a minute speck of biotite remains; and finally in fig. 12 the muscovite has usurped the whole field. The biotite is apparently being eaten away by the muscovite. Both formed at once, the biotite, the more unstable of the two species, has given way to the more hardy muscovite.

Of very different character are the occasional superficial markings of magnetite, which occur upon plates of muscovite from the same locality. These markings, sometimes known as "reticulated magnetite," are most abundant and may best be studied in the muscovite of Southern Chester and Delaware Counties in Penna., and of Brandywine Hundred, Delaware.

[1] Monatsb. d. Konigl. Acad. d. Wiss., Berlin, 1869, p. 339.

These well-known and often very beautiful markings form a series of branching lines, which run in three directions across the plates of mica, sometimes resembling the frost figures upon a window pane. The lines of the figures cross each other at fixed angles of 60°, and from their similarity to crystalline forms, have been hitherto regarded by mineralogists as the result of repeated twinning around a dodecahedral axis,[1] and have been correlated with the dendritic crystallizations of native gold and copper.[2] As shown, however, by the writer in 1877,[3] these markings always bear a fixed relation to the crystallographic axes of the muscovite, and are not due to an inherent property of the magnetite.

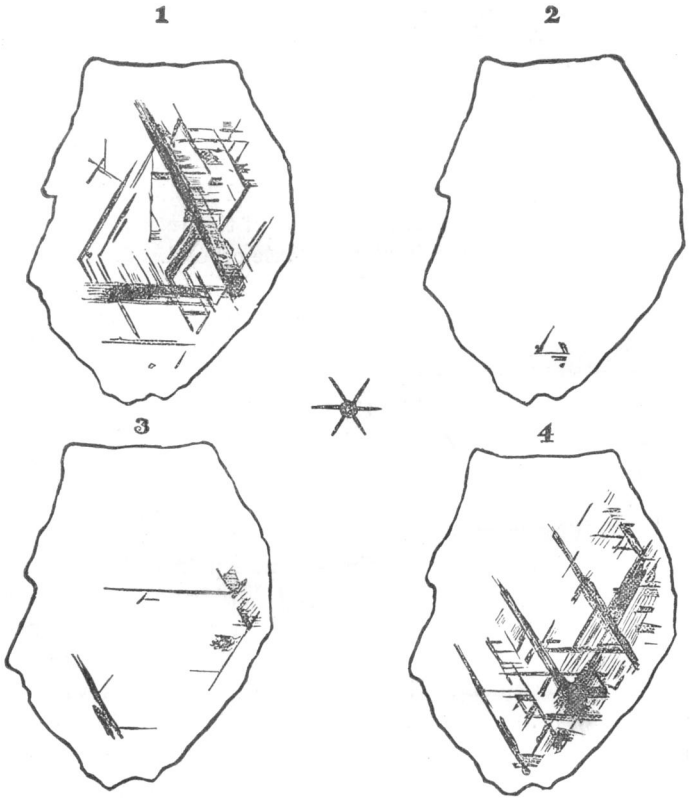
If a crystal of muscovite enclosing reticulated magnetite be dissected into a series of successive cleavage plates, it will be found that the markings throughout are confined to similar portions of the crystal and that the three directions of the lines are maintained at the same angle throughout the whole crystal. Some common cause has produced the parallelism of the lines in successive plates. On the other hand, it will be seen that there is no direct connection between any one cleavage plate and that next above or below it. One plate may be covered with markings, and the next plate entirely free from them, while the third plate will be again covered with markings, which, quite unlike the first plate in appearance and arrangement, yet form the same angles with the exterior of the crystal. Unlike the enclosed crystals of biotite, which *penetrate* the muscovite through successive plates, the reticulated magnetite is superficial, and rests upon the separate plates of muscovite in disconnected dendritic patches. The following drawing represents four successive plates of muscovite with reticulated magnetite, and shows the independence yet correlation of these markings. Lamina No. 2, which lay immediately below No. 1, is almost free from markings, while Nos. 3 and 4, cleft from the lower side of No. 2, show that the arrangement of the markings is entirely different on each lamina, although they maintain the same direction on all four. The strike figure, common to all four laminæ, is shown in the centre of the drawing. The specimen figured was obtained in Delaware, near the Pennsylvania line.

[1] J. D. Dana, System of Mineralogy, p. 150.

[2] E. S. Dana, Text book of Mineralogy, p. 93.

[3] Proc. Min. and Geol. Section, Acad. Nat. Sc., June 25, 1877.

Although always resting upon the plates of mica as very thin dendrites, the magnetite has not been derived from any external source, but evidently from the muscovite itself. The markings do not occur along lines of cracks or near the edges of the crystal, but lie in regular groups in the interior. They are not dendrites in the sense of being the result of any infiltration, and the term "dendrite" should therefore not be applied to them. They are true



"enclosures" which, like the enclosures of pyrite in calcite, or the impurities in chiastolite, are arranged with reference to the symmetry of the enclosing crystal.

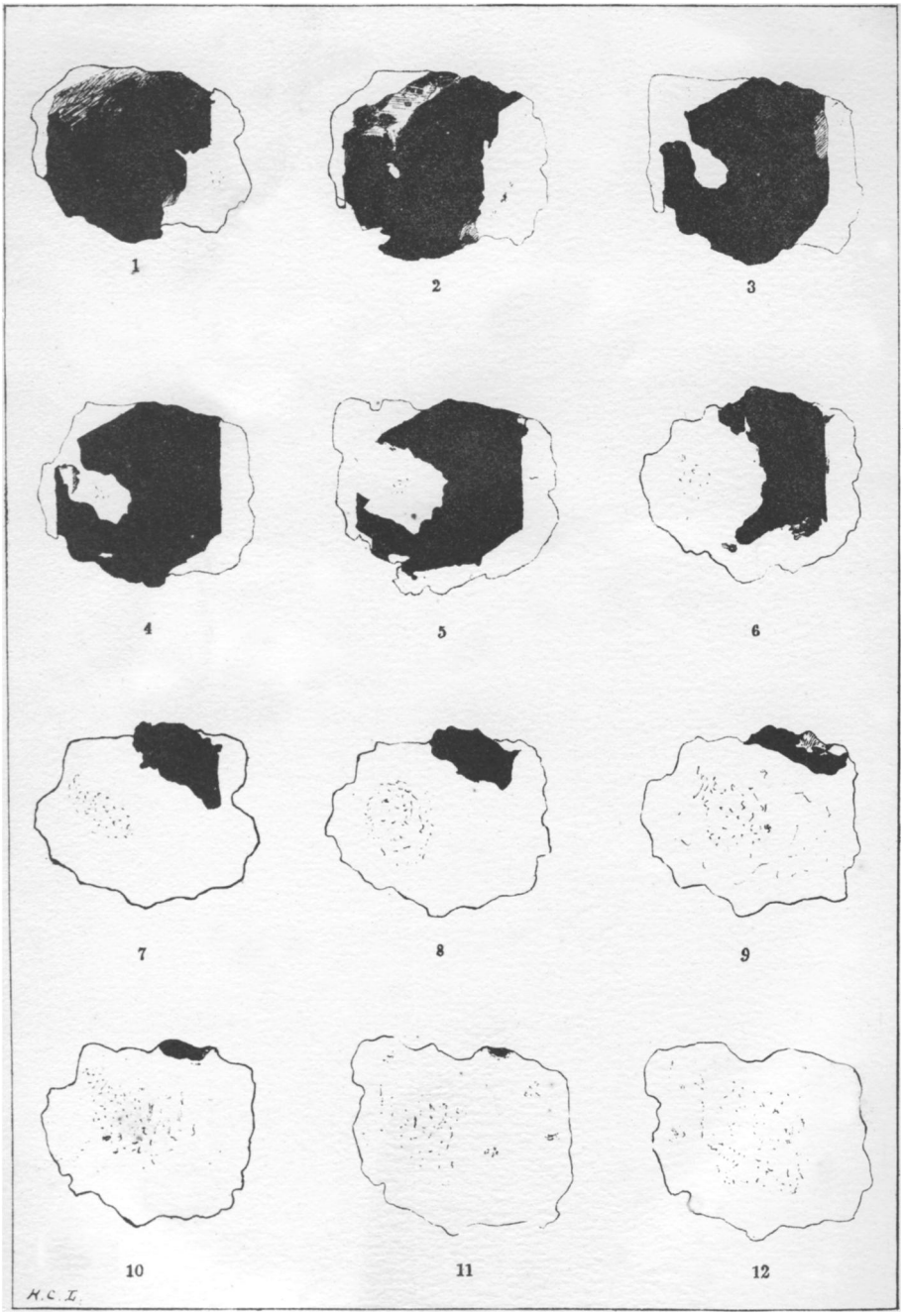
This fact is rendered even more evident when the direction of the lines of the markings is compared with the "strike figures" produced artificially upon the muscovite. The writer has found

that in all cases the markings are parallel with the lines of the strike figures. In the drawing given above, the strike figure is inserted between the figures of the muscovite, and this parallelism of direction is clearly seen.

It is thus interesting to find that a blow given with a sharp instrument was necessary to bring out lines which were previously recognized and followed by the more sensitive magnetite in its growth. Just as beryls and tourmalines and quartz crystals are flattened and garnets are laminated by the enclosing mica, so the magnetite is influenced to follow the crystallographic lines of the parent mineral. Such forms might well be designated *allomorphic*. The weaker mineral is compelled into another habit by the stronger one.

It should be mentioned that occasionally the magnetite follows lines of the natural cleavage of the muscovite, such lines being at right-angles to the lines produced in the strike figure. Fig. 1, in the preceding cut, shows these secondary lines in addition to the more prominent lines which are parallel to the strike figure.

In conclusion, then, it appears that both biotite and magnetite, when enclosed in muscovite, conform in their directions to the crystallographic planes of the latter; and that while biotite penetrates through successive plates of the muscovite, and is frequently altered into it, magnetite, on the other hand, is purely superficial and forms different markings upon each lamina of mica.



LEWIS ON ENCLOSURES IN MUSCOVITE.